PATENT ABSTRACTS OF JAPAN

(11)Publication number :   06-349701

(43)Date of publication of application : 22.12.1994

(51)Int.Cl.	H01L 21 027
	G03B 27 32
	G03F 7 20

(21)Application number : 05-141016   (71)Applicant : NIKON CORP

(22)Date of filing :   11.06.1993   (72)Inventor : NAKAJIMA TOSHIJI

                                                 HAMAYA MASATO

(54) EXPOSURE DEVICE

(57)Abstract:

PURPOSE: To reduce illuminance irregularity due to speckle pattern when using light with a high spatial coherence as exposure light by the slit scan exposure system.

CONSTITUTION: A reticle R is scanned in a scanning direction SR for a lighting region 15. a wafer W is scanned in a scanning direction SW for an exposure region 16 which is conjugate to the lighting region 15, and then the pattern of the reticle R is exposed on the wafer W successively. The spatial coherence of laser beam LB0 discharged from an excimer laser light source 1 is high in horizontal direction (H direction), its horizontal direction is made to be conjugate to the scanning direction SR of the lighting region 15 and the direction where the spatial coherence higher becomes the scanning direction SR.
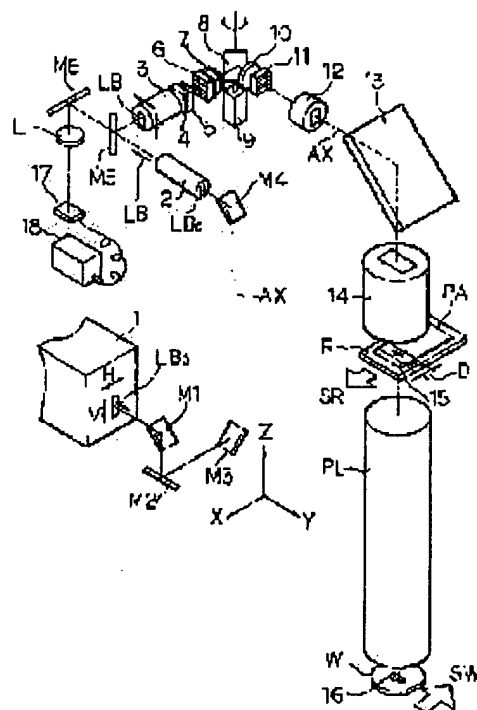
* NOTICES

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)
[Claim 1 An exposure device which is provided with the following and characterized by making the high direction of spatial coherence of said illumination light the same as that of a relative scanning direction of an illuminated field of said specified shape, and said mask in an exposure device which exposes a pattern of said mask on said substrate one by one.
A light source which generates illumination light which has predetermined spatial coherence.
An illumination-light study system which illuminates an illuminated field of specified shape by said illumination light.
A relatively scan means to synchronize and to scan a mask and a photosensitive substrate with which a pattern for transfer was relatively formed to said illuminated field.

[Claim 2 A pulse light source which generates pulsed light which has predetermined spatial coherence characterized by comprising the following, An exposure device which has an illumination-light study system which illuminates an illuminated field of specified shape by said pulsed light, and a relatively scan means to synchronize and to scan a mask and a photosensitive substrate with which a pattern for transfer was relatively formed to said illuminated field, and exposes a pattern of said mask on said substrate one by one.
A relative scan speed of an illuminated field of said specified shape, and said mask.
A phase variable means to change a phase of a speckle pattern of said pulsed light in said illuminated field for said every pulsed light according to a pitch of said relative scanning direction of a speckle pattern of said pulsed light in said illuminated field.

[Claim 3 The exposure device comprising according to claim 2:
A spatial coherence detection means to detect spatial coherence of said pulsed light.
A control means which controls operation of said phase variable means according to spatial

coherence of said detected this pulsed light.

[Translation done.]

* NOTICES

1.This document has been translated by computer. So the translation may not reflect the
original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

___

DETAILED DESCRIPTION

___

[Detailed Description of the Invention
[0001]
[Industrial Application In this invention, a rectangle or the illuminated field of circular   is
illuminated, for example by exposing light, and a mask and a sensitized substrate are
synchronously scanned to the illuminated field.
Therefore, about the so-called exposure device of the slit scan exposure system which
exposes the pattern on a mask on a sensitized substrate one by one, when using a high light
of especially spatial coherence as exposing light, it applies, and it is suitable.

[0002]
[Description of the Prior Art Conventionally, when manufacturing a semiconductor device, a
liquid crystal display element, or a thin film magnetic head using photolithography technology,
a photo mask or the pattern of reticle (it is hereafter named reticle generically) via a
projection optical system, The projection aligner exposed on the substrates (a wafer or a glass
plate) with which photoresist etc. were applied is used. In this projection aligner, in order to
carry out short wavelength formation of the exposing light and to raise resolution, a KrF
excimer laser, an excimer laser beam like an ArF excimer laser, or the laser beam of an
ultraviolet area like the harmonics of argon laser is coming to be used as exposing light.
[0003]However, spatial coherence (coherence) of a laser beam is high, and while passing an
illumination-light study system, the interference fringe called a speckle pattern arises, and it
has the problem that this becomes the illumination unevenness on reticle and a substrate.
Then, with the projection aligner of a one-shot exposure method like the conventional usual
stepper, in using a laser beam as exposing light. In order to decrease the illumination
unevenness by a speckle pattern, the vibration mirror was arranged in front of the fly eye lens
(optical integrator) in an illumination-light study system. And by scanning the laser beam which

enters among one exposure at the optical integrator by the vibration mirror, He exposes changing the phase of the speckle pattern (interference fringe) produced on reticle and a substrate, and was trying for the light exposure in the whole surface in each shot region on a substrate to become uniform. In this case, the contrast of distribution of the light exposure on a substrate becomes the minimum by shaking a vibration mirror among one exposure, so that the phase of an interference fringe may do 2pi change of.

[0004]

[Problem(s) to be Solved by the Invention The chip size of one piece of a semiconductor device tends to be enlarged these days, and large area-ization which exposes the pattern of a bigger area than that on reticle on a substrate is called for in the projection aligner. In order to respond to large-area-izing of this transferred pattern, and restriction of the exposure field of a projection optical system, For example, the so-called projection aligner of the rectangle and the slit scan exposure system which is circular or exposes the pattern on reticle on a substrate one by one by scanning reticle and a photosensitive substrate synchronously to illuminated fields (this is called "slit shape illuminated field"), such as a hexagon, is developed. To use a high light of spatial coherence like a laser beam as exposing light also with the projection aligner of such a slit scan exposure system, it is necessary to reduce the illumination unevenness by a speckle pattern.

[0005]However, in a slit scan exposure system, since reticle and a substrate are scanned, the phase in which a SUPPEKURU pattern appears carries out a temporal change. Therefore, the scanning direction of reticle and a substrate poses a problem first. Next, when using together the vibration mirror used at the time of a one-shot exposure method, it becomes a problem how a vibration mirror is controlled according to the scan speed of the scanning direction, reticle, and a substrate.

[0006]For example, pattern space PA of the reticle R is gradually scanned by the illuminated field 51 relatively, drawing 7 (a) - (d) showing the state of scanning the reticle R in the direction (scanning direction SR) of X to the slit shape illuminated field 51, and applying it to the state of drawing 7 (d) from the state of drawing 7 (a). Therefore, to the direction (non-scanning direction) vertical to the direction of X of Y, although the scan is substantially performed to the direction of X in pattern space PA of the reticle R, since it is a state of rest, the influences of a speckle pattern differ in the scanning direction and the non-scanning direction.

[0007]An object of this invention when using a high light of spatial coherence as exposing light with the exposure device of a slit scan exposure system in view of this point is to make illumination unevenness by a speckle pattern as small as possible.

[0008]

[Means for Solving the Problem As shown, for example in drawing 1 and drawing 2, the 1st exposure device by this invention, A light source (1) which generates illumination light (LB_0)

which has predetermined spatial coherence, An illumination-light study system (2-14) which illuminates an illuminated field (15) of specified shape by the illumination light, It has a relatively scan means (32, 34, 35, RST, WST) to synchronize and to scan a mask (R) and a photosensitive substrate (W) with which a pattern for transfer was relatively formed to an illuminated field (15), In an exposure device which exposes a pattern of a mask (R) on a substrate (W) one by one, the high direction (direction H) of spatial coherence of illumination light (LB$_0$) is made the same as that of an illuminated field (15) of specified shape, and a relative scanning direction (direction SR) with a mask (R).

[0009]As shown, for example in drawing 1 and drawing 2, the 2nd exposure device by this invention, A pulse light source (1) which generates pulsed light (LB$_0$) which has predetermined spatial coherence, An illumination-light study system (2-14) which illuminates an illuminated field (15) of specified shape by the pulsed light, It has a relatively scan means (32, 34, 35, RST, WST) to synchronize and to scan a mask (R) and a photosensitive substrate (W) with which a pattern for transfer was relatively formed to an illuminated field (15), In an exposure device which exposes a pattern of a mask (R) on a substrate (W) one by one, An illuminated field (15) of specified shape, and a relative scan speed with a mask (R), According to a pitch of the relative scanning direction (direction SR) of a speckle pattern of the pulsed light in an illuminated field (15), a phase variable means (8, 9) to change a phase of a speckle pattern of the pulsed light in an illuminated field (15) for every pulsed light of the is formed.

[0010]In this case, it is desirable to establish a spatial coherence detection means (17, 18) to detect spatial coherence of that pulsed light, and a control means (32) which controls operation of a phase variable means (8, 9) according to spatial coherence of that pulsed light detected in this way.

[0011]

[Function]According to the 1st exposure device of this this invention, the high direction of spatial coherence (coherent grade) is beforehand measured in the field vertical to the light flux of the illumination light (LB$_0$), In the illuminated field (15) of specified shape, the high direction of the spatial coherence is doubled towards the relative scan with a mask (R) (the direction of SR). Therefore, as shown, for example in drawing 4, the illuminance distribution of the scanning direction (the direction of SR) of the speckle pattern by the illumination light formed on an illuminated field (15) is changed with comparatively large amplitude with a predetermined pitch like the distribution curve 40. The illuminance distribution of the non-scanning direction (the direction of Y) of the speckle pattern on the illuminated field (15) is comparatively flat like the distribution curve 41. In this case, in a scanning direction, since the illuminance distribution of each point on a mask (R) becomes being the same as that of the case where changed like the distribution curve 40, respectively and it scans by a vibration

mirror substantially, there is little illumination unevenness. In a non-scanning direction, from the first, since there is little illumination unevenness, its illumination unevenness decreases all over a mask (R) and a substrate (W).

[0012]According to the 2nd exposure device of this invention, pulsed light is used as illumination light. Since it is not easy to erase the chromatic aberration in an optical system when pulsed light is an excimer laser beam (wavelength is 248 nm) of a far ultraviolet region, in a pulse light source (1), the pulsed light which narrow-band-ized spectral line width is generated by using a diffraction grating, a slit, etc. Therefore, in drawing 1, as for the pulsed light (LB_0) ejected from a light source (1), spatial coherence becomes low, and although spatial coherence becomes high horizontally (the direction of H) and the beam width is narrow, perpendicularly (the direction of V), the beam width is large. Therefore, in this invention, the horizontal direction of the pulsed light (LB_0) ejected from a light source (1) is set as the scanning direction of the slit shape illuminated field (15) on a mask (R).

[0013]In this case, the ratio of the horizontal width of that pulsed light (LB_0) and vertical width, Generally, since it is smaller than the ratio of the width of the scanning direction of the slit shape usual illuminated field (15), and the width of a non-scanning direction, it is necessary using the two cylindrical lenses 38 and 39 as shown, for example in drawing 3 to expand the horizontal width of the pulsed light (LB_0). If the focal distance of the cylindrical lens 39 of f_1 and the latter part is made into f_2 for the focal distance of the cylindrical lens 38 of $theta_1$ and the preceding paragraph, the spread angle of the pulsed light (LB_0) which enters at this time, Spread angle $theta_2$ of the pulsed light (LB) ejected from the cylindrical lens 39 is as follows.

[0014]$theta_2 = (f_1/f_2) \, theta_1$ (1)

Therefore, in order to expand a horizontal beam width, if $f_1 < f_2$, it will be as follows and spread angle $theta_2$ of the pulsed light (LB) ejected will become small.

$theta_1 > theta_2$ (2)

Therefore, if a beam width is expanded horizontally, as shown in drawing 4, the spatial coherence in the scanning direction (the direction of SR) of an illuminated field (15) will become still higher. Therefore, the high speckle pattern of contrast is formed in a scanning direction. On the other hand, since the contrast of the speckle pattern of a non-scanning direction is low, there is little illumination unevenness in a non-scanning direction.

[0015]The illuminance distribution of the scanning direction of the illuminated field (15) becomes like the distribution curve 40 of drawing 5 (a). Since it will become superposition of the wave of various phases like drawing 5 (b) by the phase shift by scan if the scanning direction of a mask and a substrate is chosen in this direction, it counts upon mitigation of a

speckle according to a superimpose effect. However, when not performing a certain control, depending on a scan speed. The timing of pulse radiation and the phase of a speckle pattern become a form mostly in agreement, and in a certain irradiation point on a mask (R). For example, exposure is performed in order of the positions 40C and 40F of drawing 5 (a), and --, in another irradiation point, exposure is performed in order of the positions 40B and 40E and --, a superimpose effect cannot be expected, and illumination unevenness may not be reduced. In order to avoid this, when it is the scan speed that pulse radiation is performed, a vibration mirror is made to scan in the positions 40C, 40F, and 40I of drawing 5 (a), and when emitting light in the position 40F and emitting light in deltaA and the position 40I, scanning controls in which only deltaB carries out a strike slip are carried out.

[0016]Thereby, since each irradiation point on a mask (R) is exposed with illumination with a SUPPEKURU pattern of a phase which is equally divided according to a pulse number and is different called the distribution curves 40, 42, and 43 of drawing 5 (b), an integrated exposure is equalized and the illumination unevenness in the scanning direction on a mask (R) is reduced. Namely, n and m are made into an integer in the arbitrary irradiation points on a mask (R), So that the phase of the scanning direction on the distribution curve 40 may become 0, 2mpi+ (2 pi/n), 4mpi+ (4 pi/n), 6mpi+ (6 pi/n), ..., 2(n-1)mpi+2 (n-1) pi/n, and ... for every pulse radiation, The illumination unevenness of a scanning direction is reduced by controlling operation of a phase variable means (8, 9).

[0017]A spatial coherence detection means (17, 18) to detect the spatial coherence of the pulsed light, When the control means (32) which controls operation of a phase variable means (8, 9) according to the spatial coherence of the pulsed light detected in this way is established, Operation of a phase variable means (8, 9) is controlled so that the illumination unevenness resulting from the speckle pattern on a mask (R) and a substrate (W) becomes the minimum according to the detected spatial coherence.

[0018]

[Example Hereafter, with reference to drawings, it explains per example of the exposure device by this invention. This example applies this invention to the projection aligner of the slit scan exposure system which uses a pulse oscillation type laser light source as a light source of exposing light. Drawing 1 shows the optical system of the projection aligner of this example, and laser beam LB_0 of the far ultraviolet region (wavelength is 248 nm) ejected from the excimer laser 1 in this drawing 1, It enters into the beam shaping optical system 2 which contains a cylindrical lens via the purple external use reflective mirror M1, M2, M3, and M4. The sectional shape of laser beam LB_0 ejected from the excimer laser 1 is a long and slender rectangle whose horizontal (the direction of H) width is quite narrower than vertical (the direction of V) width.

In the beam shaping optical system 2, the horizontal width of laser beam LB_0 is expanded and the laser beam LB of the sectional shape of the almost same aspect ratio as the aspect ratio of the slit shape below-mentioned illuminated field 15 is ejected.

[0019]As drawing 3 shows the composition of the beam shaping optical system 2 and shows it to this drawing 3, entering laser beam LB_0, pass the cylindrical lens 38 of focal distance f_1, and the cylindrical lens 39 of focal distance f_2 $(f_2 > f_1)$ -- the horizontal width of sectional shape is expanded f_2/f_1 twice. If the spread angle of entering laser beam LB0 is made into $theta_1$, spread angle $theta_2$ of the laser beam LB ejected will decrease to f_1/f_2 of spread angle $theta_1$. Generally, since the spatial coherence of light flux is so high that a spread angle is small, the spatial coherence of the horizontal direction (the direction of H) of the laser beam LB ejected is raised rather than entering laser beam LB_0.

[0020]The laser beam LB which returned to drawing 1 and was ejected from the beam shaping optical system 2 is bent by the purple external use reflective mirror M5, and enters into the beam expander (or zoom lens) 3, and sectional shape is expanded even to a predetermined cross section size. The parallel laser beam LB ejected from the beam expander 3 enters into the crystal prism 4 as a polarization means, and is divided into two polarization components which intersect perpendicularly. Two polarization components separated in this way enter into the quartz glass prism 5 for optical-path amendment, and the direction of movement of a beam is amended. Then, the laser beam of two polarization components is bent by the vibration mirror 8 through the 1st step of the fly eye lens 6 and the relay lens 7. With the drive 9, the vibration mirror 8 scans a laser beam by the suitable control method in an angle range predetermined [on the level surface .

[0021]The laser beam scanned by the vibration mirror 8 enters into the 2nd step of fly eye lens 11 through the relay lens 10, Image formation of many 3rd light sources (spot light) is carried out to the focal plane by the side of the ejection, and it is further condensed by the condenser 12, and the laser beam from the 3rd light source of these large number bends by the mirror 13, and enters into ********** and the main condenser lens 14. With the main condenser lens 14, the width of the short side direction on the reticle R carries out weight of the laser beam from many 3rd light sources to the illuminated field 15 of the rectangle of D, and is irradiated with it. Image formation projection of the pattern image in the illuminated field 15 is carried out into the exposure region 16 of the rectangle on the wafer W via projection optical system PL.

[0022]In this case, the Z-axis is taken in parallel with the optic axis of projection optical system PL, and the X-axis in an XY plane vertical to that optic axis is taken to the short side direction of the rectangular illuminated field 15. And in this example, set projecting magnification of

projection optical system PL to beta, and it synchronizes with scanning the reticle R at the speed V in the direction (this is set to scanning direction SR) of X to the illuminated field 15, By scanning the wafer W by speed beta-V in the direction (let this be the scanning direction SW) of -X, projection exposure of the circuit pattern image in pattern space PA of the reticle R is carried out to the shot region of the wafer W one by one.

[0023]In drawing 1, in order to investigate the spatial coherence of an excimer laser beam, Install the condenser L1 behind the purple external use reflective mirror M5, the rear side focal position of the condenser L1 is made to condense the light leaking in the purple external use reflective mirror M5, and the light leaking distributed in two dimensions with the two-dimensional image sensor 17 which consists of CCD installed in the focal position is received. And the angle of divergence of the laser beam was measured by processing the imaging signal from the two-dimensional image sensor 17 by the image processing system 18. Since the angle of divergence of a laser beam has a relation of reverse proportion to spatial coherence, it can compute scanning direction SR on the illuminated field 15, and the spatial coherence of a non-scanning direction by the measured angle of divergence.

[0024]Drawing 2 shows the control system of the projection aligner of drawing 1, and in this drawing 2 in the excimer laser 1, The electrode the gas used as the medium of laser oscillation, and for oscillation triggers. The prism 24 for the enclosed laser tube 21, the front mirror 22 with the predetermined reflectance (less than 100%) which constitutes a resonator, the rear mirror 23 of the resonator, the opening plate 29 for wavelength selections, wavelength selection, and the formation of a wavelength narrow band, and reflection type diffraction grating 25 grade, It is provided as an optical element. In order to always make regularity the oscillation controlling part 26 for making it oscillate by impressing high tension to the electrode in the laser tube 21 to the excimer laser 1, and the absolute wavelengths of the laser beam oscillated, The actuator 28 grade for adjusting inclination of the wavelength adjustment actuator 27 which adjusts the angle of inclination of the diffraction grating 25, and the rear mirror 23 is provided.

[0025]A part of laser beam ejected from the front mirror 22 is led to the wavelength detectors (spectroscope etc.) 3 via the beam splitter 30, and the wavelength which detected and detected the wavelength of the laser beam with the wavelength detector 31 is transmitted to the wavelength adjustment actuator 27. The wavelength adjustment actuator 27 changes the angle of inclination of the diffraction grating 25 so that a difference with the absolute wavelengths defined beforehand may come in a standard according to the wavelength detected with the wavelength detector 31. The signal according to the beam angle of divergence which processes the imaging signal from the two-dimensional image sensor 17 by the image processing system 18, and is detected. (The signal according to the size of the beam spot specifically made on the two-dimensional image sensor 17) is fed back to the

actuator 28 of the rear mirror 23 of the excimer laser 1, and it is sent also to the main control unit 32 which controls operation of the whole device. The actuator 28 changes the angle of inclination of the rear mirror 23, when the value of the angle of divergence of the beam surveyed to the value defined beforehand has separated more than tolerance level.

[0026]Positioning and a scan of the reticle R of drawing 1 are performed by the reticle stage RST of drawing 2, and positioning and a scan of the wafer W are performed by the wafer stage WST of drawing 2. The reticle stage RST scans the reticle R, in order to change the irradiation area of the reticle R on which the pattern of one chip was drawn one by one. The wafer stage WST so that the pattern image of the reticle R may be exposed to each of two or more shot regions on the wafer W, It has the function to move the wafer W in the direction of X, and the direction of Y by a step-and-repeat method, and a function which scans the wafer W synchronizing with the scan of the reticle R according to the irradiation area of the reticle R.

[0027]The main control unit 32 controls the oscillation of the excimer laser 1 via the oscillation controlling part 26, and controls operation of the wafer stage WST and the reticle stage RST via the wafer stage control system 34 and the reticle stage control system 35, respectively. And the main control unit 32 controls amplitude, a cycle, etc. of vibration of the vibration mirror 8 via the drive 9. The indicator (CRT display, meter, etc.) 33 grade as the keyboard 36, the device for inputting coordinates (what is called a mouse) 37, and output unit as an input device is connected to the main control unit 32. The keyboard 36 and the device for inputting coordinates 37 are used [by a what pulse it exposes per 1 shot region in the exposing treatment of a certain wafer, and] for [other than specifying beforehand] various sequence setting out or parameter setting.

[0028]The main control unit 32 without receiving the information on the beam angle of divergence of the laser beam from the excimer laser 1 under preliminary oscillation from the image processing system 18 and lowering a throughput, The oscillating frequency optimized so that a speckle pattern might be made the smallest, and the pulse number of the laser beam irradiated by one shot region on the wafer W are determined, and instructions are emitted to the oscillation controlling part 26. In parallel, the main control unit 32 determines the oscillation period of the vibration mirror 8, amplitude, and a phase, emits instructions to the drive 9, and determines the optimal scan speed as the reticle stage control system 35 and the wafer stage control system 34, and issues instructions.

[0029]Next, it explains per composition for reducing the illumination unevenness on the reticle R and the wafer W by this example. First, in this example, the spatial coherence of laser beam LB_0 ejected from the excimer laser 1 in drawing 1 is high horizontally (the direction of H). Then, an illumination-light study system is constituted so that the high direction of the spatial coherence of the laser beam LB_0 may be set to the short side direction, i.e., scanning direction SR, of the illuminated field 15. Thereby, the speckle pattern of the laser beam formed on the

illuminated field 15 on the reticle R has the high contrast of scanning direction SR, and the contrast of the non-scanning direction (the direction of Y) is low.

[0030]The periodic ingredient corresponding to the arrangement of the lens element of the fly eye lenses 6 and 11 is contained in the speckle pattern generated on the reticle R of drawing 1, and the wafer W.

The contrast of this interference pattern becomes high in the direction of X on the reticle R. In this example, in order to reduce the contrast of a speckle pattern, the laser beam LB is divided into the laser beam of two polarization components which makes a predetermined angle with the crystal prism 4 as a polarization means, and the reticle R is illuminated. Illuminance distribution I(X) (relative value) of the scanning direction (the direction of X) of the illuminated field 15 by the laser beam of the 1st polarization component of the two polarization components is changing periodically with the predetermined pitch like the distribution curve 40 of drawing 6 (a). On the other hand, illuminance distribution I(X) by the laser beam of the 2nd polarization component is shifted in the direction of X only half a pitch to the distribution curve 40, as the distribution curve 44 shows. Thereby, the whole illuminance distribution I(X) becomes the distribution curve 45 of drawing 6 (b), and the amplitude of change of illuminance distribution is reduced.

[0031]Drawing 4 shows the illuminance distribution of the illuminated field 15 on the reticle R of this example, and on the reticle R, as shown in drawing 4 (a), the illuminated field 15 of the width D of scanning direction SR (the direction of X) is formed. And illuminance distribution I(X) of the direction of X of the illuminated field 15 changes with comparatively big amplitude with a predetermined pitch like the distribution curve 40 of drawing 4 (b), and the illuminance distribution I (Y) of the direction of Y of the illuminated field 15 is almost flat like the distribution curve 41 of drawing 4 (c). Therefore, the illumination unevenness in the direction of Y which is a non-scanning direction is small. In this example, the illumination unevenness in the direction of X is canceled by the scan of the reticle R to the illuminated field 15, and the scan of the laser beam by the vibration mirror 8 of drawing 1.

[0032]Drawing 5 (a) shows the distribution curve 40 corresponding to illuminance distribution I (X) of the scanning direction per 1 pulsed light in the illuminated field 15 (the direction of X), and an X coordinate is   the field to D   an inside of the illuminated field 15 of drawing 4 (a) from the starting point. moreover -- if the reticle R is scanned in the direction of X to the illuminated field 15 -- each irradiation point on the reticle R -- drawing 5 (a) -- (-- drawing 5 (b) -- the same --) -- it shall move along with the X-axis

[0033]When setting to n the required pulse number to which pulse radiation is performed and which is asked for the pitch of the distribution curve 40 from the energy density and sensitivity of resist of PX and one pulse in this example, by n pulse radiation. The scan speed that 0, PX n, 2 PX n, ..., the distribution curve that has a peak in each position of PX n (n-1) are

acquired (0, PX n, 2 PX n, ..., the distribution curve that has a peak in order of PX n (n-1) do not need to appear.) By n pulse radiation, all the distribution curves that have a peak in each position should just be acquired. moreover -- n is large enough -- pitch PX -- n/2, n/3, and ... the distribution curve which has a peak in the position divided equally is just acquired. When in agreement with the speed (value V (D n) f which broke the irradiation area D by required pulse number n, and applied the oscillating frequency f of laser) determined beforehand, it is not necessary to make the vibration mirror 8 of drawing 1 scan, and the illumination unevenness on the reticle R and the wafer W is reduced most efficiently.

[0034]For example, when a required pulse number is 3, the reticle R moves in the direction of X only D 3 for every pulse. Therefore, as shown in drawing 5 (a), in a certain irradiation point (X 0) on the reticle R. Since of the positions 40A, 40E and 40I of interval D 3, and --] the pulse of the distribution curves 40, 42, and 43 of drawing 5 (b) will become should pile up if exposure is performed in order and the exposure value distribution of the direction of X is seen, the light volume unevenness of an integrated exposure becomes very small. The distance which the reticle R moves for every pulse is beforehand set as 1 for the integer of the width D of the scanning direction of the illuminated field 15.

[0035]However, since the scan speed of the reticle R and the wafer W is determined like the after-mentioned by the amount of appropriate exposure on the wafer W, etc., the aforementioned conditions may not necessarily be satisfied. In such a case, the vibration mirror 8 of drawing 1 is scanned and 0, PX n, 2 PX n, ..., the distribution curve that has a peak in the position of PX n (n-1) need to be made to be acquired.

[0036]When a required pulse number is 4, the reticle R moves to a concrete target only D 4 in the direction of X for every pulse. Therefore, as shown in drawing 5 (a), in a certain irradiation point (X 0) on the reticle R. Intervals are D 4 of the positions 40A, 40D, 40G, and 40K... Exposure is performed in order and in a certain another point and the point which separated only D 6 from the position of X 0. Since exposure is performed in order of the positions 40C, 40F, 40I, and 40L, the distribution curve 40 becomes should pile up distribution of the integrated exposure of the direction of X, and mitigation of light volume unevenness is not carried out at all. Then, the vibration mirror 8 is made to scan. For example, it becomes superposition of the wave of four kinds of phases which are different like drawing 5 (c) when, as for the time of PX 4, and the position 40I, only 3Ps X 4 change a phase by the scan of the vibration mirror 8 at the time of PX 2, and the position 40L at the time of exposure in the position 40F, and illumination unevenness becomes very small. By drawing 5 (c), as for the distribution curves 46, 47, and 48, only PX 4, PX 2, and 3Ps X 4 change a phase by the vibration mirror 8 from the distribution curve 40, respectively.

[0037]Next, it explains per scan speed of the reticle R and the wafer W. The scan speed of the wafer W is first determined by the amount of appropriate exposure (this becomes settled with

the sensitivity of the resist applied on the wafer W) given to the wafer W, and the amount of energy for every pulse. Since the amounts of energy emitted for every pulse differ in the case of a light source like the excimer laser 1, It dims in an illumination-light study system, and by increasing and exposing a pulse number, the amount of energy for every pulse is determined so that dispersion in the light exposure given to the wafer W by the superimpose effect may decrease.

[0038]If E and the amount of energy (the amount of average energies) for every pulse are made into E_p, the amount of appropriate exposure given to a wafer, Since the length (namely, width of the scanning direction of the illuminated field 15) of the scanning direction of the range which the number of exposure pulses is expressed with E E_p, and is illuminated at once on the reticle R is D, The movement magnitude of the reticle R for every pulse is set to D (E_p/E), and when the oscillating frequency of the excimer laser 1 is f Hz , the scan speed V of the reticle R is set as the value of a following formula.

[0039]V (E_p/E) f·D (3)

Although the scan of the speckle pattern to the non-scanning direction (the direction of Y of drawing 4) of the illuminated field 15 was omitted in the above-mentioned example, In order to reduce the illumination unevenness of a non-scanning direction more, it is desirable by shaking the vibration mirror 8 perpendicularly, for example in drawing 1 to scan a speckle pattern also to a non-scanning direction.

[0040]In drawing 4, in order to vibrate a speckle pattern to both scanning direction SR (the direction of X), and a non-scanning direction (the direction of Y), a speckle pattern may be vibrated in the direction which crosses in the direction of X, and the direction of Y.

[0041]There are also the following techniques in the method where spatial coherence coincides a high direction and scanning direction.

** If reticle and a wafer are constituted from a main part side of an exposure device in X and Y both directions so that a scan is possible, even if it is after connecting a main part and a laser light source, coherence should just make a high direction a scanning direction. At this time, it is necessary to set up the shape of an illuminated field with a reticle blind so that this determined scanning direction may turn into the transverse direction of the illuminated field on reticle.

** The high direction of the spatial coherence of the laser beam from a laser light source should just adjust with two or more mirrors the high direction of the coherence of the laser beam which enters into the illumination-light study system of an exposure device so that it may be in agreement with a scanning direction, for example. However, it may be necessary to adjust a fly eye lens etc. It is desirable to construct a device in consideration of the high direction of coherence generally.

[0042]When using the laser beam which this invention is not limited to the above-mentioned

example, for example, consists of harmonics of an YAG laser as exposing light, or when using continuation light like i line of a mercury lamp as exposing light, of course, various composition can be taken in the range which does not deviate from the gist of this invention.

[0043]

[Effect of the Invention According to the 1st exposure device of this invention, since the high direction of the contrast of the interference fringe of a SUPPEKURU pattern is reduced by relative scan with an illuminated field and a mask (substrate) in accordance with a scanning direction as for the illumination unevenness of the scanning direction, there is an advantage whose illumination unevenness by a speckle pattern becomes small.

[0044]According to the 2nd exposure device, the relative scan speed of an illuminated field and a mask, Since the phase of the speckle pattern of the pulsed light in an illuminated field can be changed for every pulsed light according to the pitch of the relative scanning direction of the speckle pattern of the pulsed light in the illuminated field, there is an advantage which can make illumination unevenness by a speckle pattern small.

[0045]Especially when a spatial coherence detection means to detect the spatial coherence of pulsed light, and the control means which controls operation of a phase variable means according to the spatial coherence of the pulsed light detected in this way are established, illumination unevenness by a speckle pattern can be made small.

[Translation done.]

* NOTICES

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings

[Drawing 1 It is a perspective view showing the projection aligner of one example of this invention.

[Drawing 2 It is a block diagram showing the control system of the projection aligner of an example.

[Drawing 3 It is a lineblock diagram showing an example of the beam shaping optical system 2 of drawing 1.

[Drawing 4 It is a perspective view showing the illuminance distribution of the illuminated field 15 on the reticle R.

[Drawing 5 The figure in which (a) shows the illuminance distribution of the scanning direction of the illuminated field 15 on the reticle R, (b), and (c) are the figures showing the illuminance distribution of the scanning direction of the illuminated field 15 in the case of vibrating a speckle pattern, respectively.

[Drawing 6 The figure showing two illuminance distribution of the illuminated field 15 in case (a) illuminates the illuminated field 15 by the laser beam from a 2-way, and (b) are the figures showing the illuminance distribution of the sum of two illuminance distribution of drawing 6 (a).

[Drawing 7 It is a figure showing the situation of a scan of the reticle to a slit shape illuminated field.

[Description of Notations

1 Excimer laser

6 and 7 Fly eye lens

8 Vibration mirror

15 Illuminated field

17 Two-dimensional image sensor

18 Image processing system

R Reticle
PL Projection optical system
W Wafer
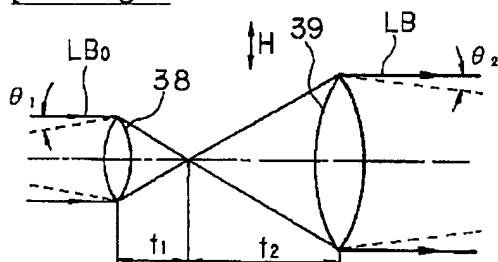RST Reticle stage
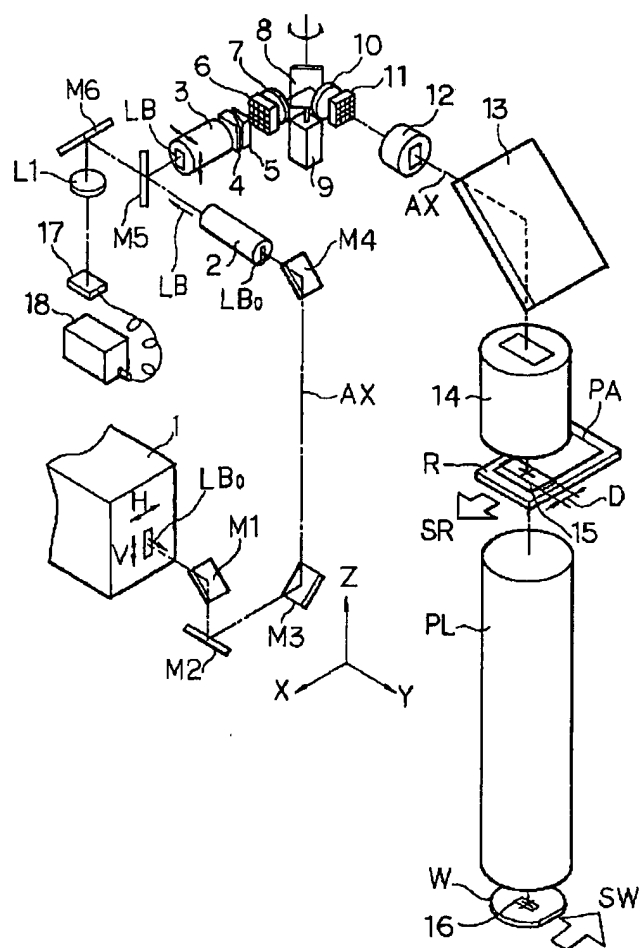WST Wafer stage

---

[Translation done.]

* NOTICES

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

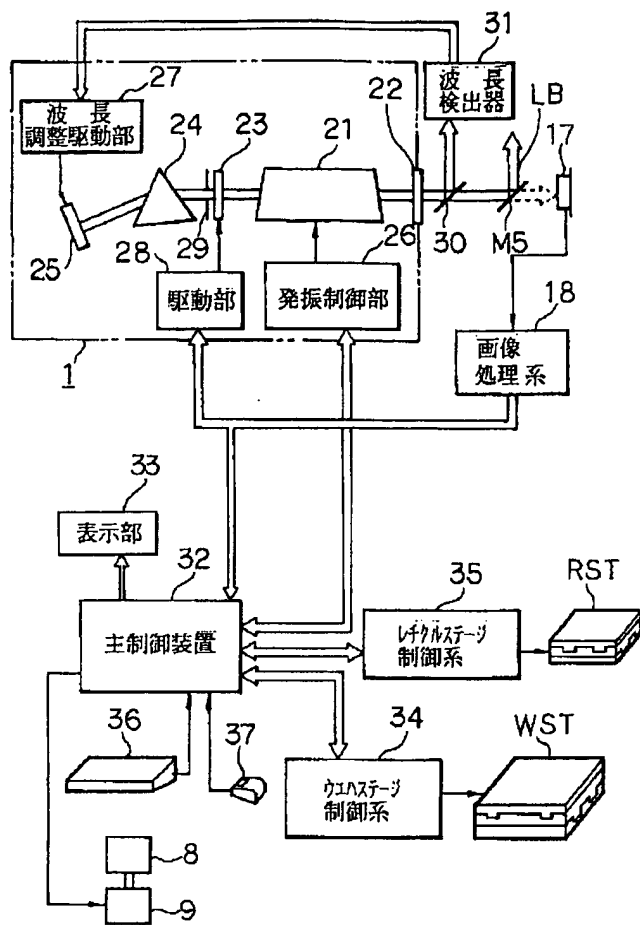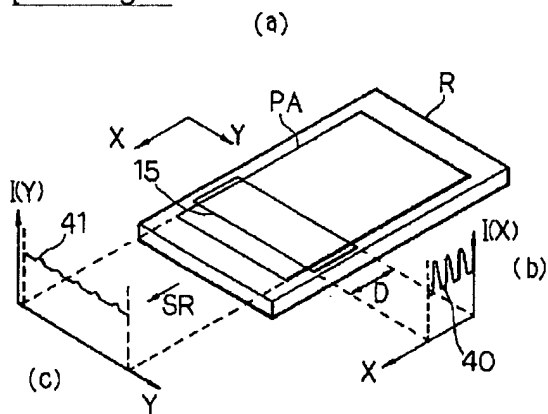3.In the drawings, any words are not translated.
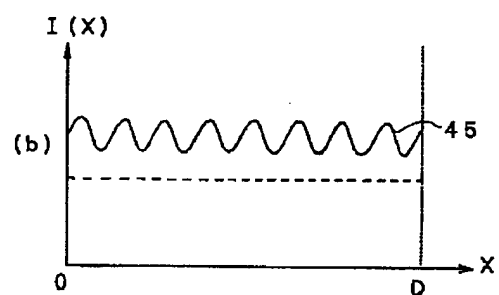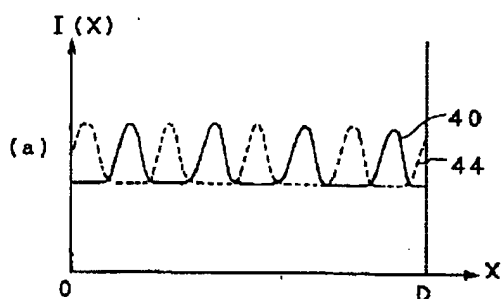

DRAWINGS

[Drawing 3

[Drawing 1

[Drawing 2

31

27 波長調整駆動部

24 23 21 22 波長検出器 LB

17

25 28 29 26 30 M5

1 駆動部 発振制御部

18 画像処理系

33 表示部

32 主制御装置

35 レチクルステージ制御系 RST

36 37 34 ウエハステージ制御系 WST

8

9

[Drawing 4

(a)

PA R

X Y

15

I(Y)

41

SR

I(X)

D

(b)

(c) X

Y

40

[Drawing 6

I(X)

(a)

40
44

0   D   X

I(X)

(b)

45

0   D   X

[Drawing 5

I(X)

PX

(a)

40C
40D   40F   40I   40L
40H   40
40B   40E   40G   40K
40A   40J

0   D   X

I(X)

(b)

43
42
40

0   D   X

I(X)

(c)

48   47   46
40

0   D   X
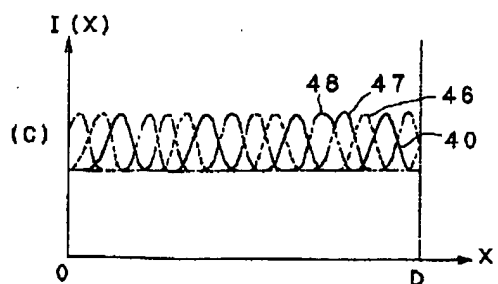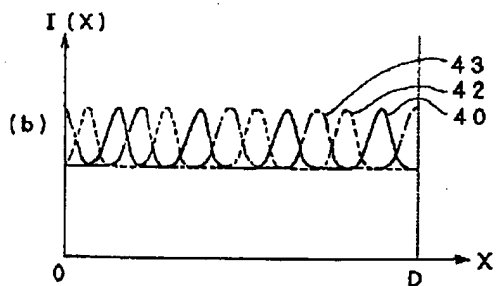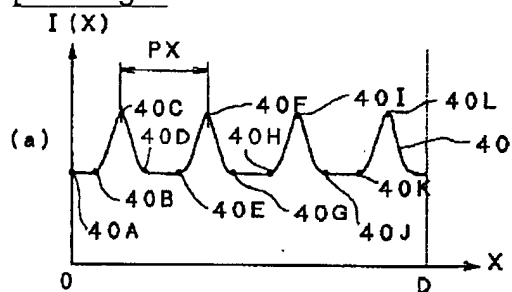
[Drawing 7

[Translation done.]

* NOTICES

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CORRECTION OR AMENDMENT

[Kind of official gazette Printing of amendment by the regulation of 2 of Article 17 of Patent Law

[Section classification] The 2nd classification of the part VII gate
[Publication date March 23, Heisei 13 (2001.3.23)

[Publication No. JP,6-349701,A
[Date of Publication December 22, Heisei 6 (1994.12.22)
[Annual volume number Publication of patent applications 6-3498
[Application number]Japanese Patent Application No. 5-141016
[The 7th edition of International Patent Classification

H01L 21/027

G03B 27/32

G03F 7/20 521
[FI

H01L 21/30 311 L

G03B 27/32 F

G03F 7/20 521

H01L 21/30 311 S
[Written amendment
[Filing date]May 31, Heisei 12 (2000.5.31)
[Amendment 1]
[Document to be Amended Specification
[Item(s) to be Amended The name of an invention

[Method of Amendment]Change

[Proposed Amendment

[Title of the Invention An <u>exposure method and</u> a device

[Amendment 2]

[Document to be Amended Specification

[Item(s) to be Amended Claim

[Method of Amendment]Change

[Proposed Amendment

[Claim(s)

[Claim 1 A light source which generates illumination light which has <u>spatial coherence</u>, and an illumination-light study system which illuminates an illuminated field of specified shape by said illumination light, In an exposure device which has a relatively scan means to synchronize and to scan a mask and a <u>substrate</u> with which a <u>predetermined</u> pattern was relatively formed to said illuminated field, and carries out <u>scanning exposure of said substrate</u>,

An exposure device making the high direction of spatial coherence of said illumination light the same as that of a relative scanning direction of an illuminated field of said specified shape, and said mask.

[Claim 2 The exposure device according to claim 1, wherein the high direction of spatial coherence of said illumination light is a direction with high contrast of a speckle pattern formed in said illuminated field.

[Claim 3 The exposure device according to claim 1 or 2 having further a displacement means which displaces a speckle pattern of said illumination light formed in said illuminated field in said illuminated field.

[Claim 4 The exposure device according to claim 3, wherein said displacement means displaces said speckle pattern towards said relatively scan.

[Claim 5 The exposure device according to claim 3 or 4, wherein said displacement means displaces said speckle pattern in the direction of said relatively scan, and the crossing direction.

[Claim 6 The exposure device according to claim 5, wherein the direction of said relatively scan and a crossing direction are directions with low contrast of said speckle pattern.

[Claim 7 Said light source is a pulse light source which carries out pulse radiation of said illumination light,

An exposure device of claim 3-6, wherein said displacement means displaces said speckle pattern synchronizing with said pulse oscillation given in any 1 paragraph.

[Claim 8 A pulse light source which generates pulsed light which has <u>spatial coherence</u>, and an illumination-light study system which illuminates an illuminated field of specified shape by said pulsed light, In an exposure device which has a relatively scan means to synchronize and

to scan a mask and a <u>substrate</u> with which a <u>predetermined</u> pattern was relatively formed to said illuminated field, and carries out <u>scanning exposure of said substrate</u>,

An exposure device comprising:

A relative scan speed of an illuminated field of said specified shape, and said mask.

A phase variable means to change a phase of a speckle pattern of said pulsed light in said illuminated field for said every pulsed light according to a pitch of said relative scanning direction of a speckle pattern of said pulsed light in said illuminated field.

[Claim 9 The exposure device comprising <u>according to claim 8</u>:

A spatial coherence detection means to detect spatial coherence of said pulsed light.

A control means which controls operation of said phase variable means according to spatial coherence of said detected this pulsed light.

[Claim 10 A light source which generates illumination light which has spatial coherence, and an illumination-light study system which illuminates an illuminated field of specified shape by said illumination light, In an exposure device which has a relatively scan means to synchronize and to scan a mask and a substrate with which a predetermined pattern was relatively formed to said illuminated field, and carries out scanning exposure of said substrate,

A displacement means which displaces a speckle pattern of said illumination light formed in said illuminated field in said illuminated field,

A control means which controls said displacement means so that influence of a speckle pattern formed in said illuminated field is reduced, while said mask and said substrate are moving to said illuminated field during said scanning exposure,

An exposure device characterized by preparation   .

[Claim 11 The exposure device according to claim 10, wherein said control means controls said displacement means so that said speckle pattern is displaced in said direction of a relatively scan.

[Claim 12 The exposure device according to claim 11, wherein said control means controls said displacement means according to a relative scan speed of said illuminated field and said mask.

[Claim 13 The exposure device according to claim 11 or 12, wherein said control means controls said displacement means according to illuminance distribution of said speckle pattern.

[Claim 14 An exposure device of claim 10-13, wherein said control means controls said displacement means so that said speckle pattern is displaced in the direction of said relatively scan, and the crossing direction given in any 1 paragraph.

[Claim 15 Said light source is a pulse light source which carries out pulse radiation of said

illumination light,

An exposure device of claim 10-14, wherein said displacement means displaces said speckle pattern synchronizing with said pulse oscillation given in any 1 paragraph.

[Claim 16 It has further a detection means to detect spatial coherence of said illumination light, An exposure device of claim 10-15, wherein said control means controls said displacement means according to spatial coherence detected by said detection means given in any 1 paragraph.

[Claim 17 A light source which generates illumination light which has spatial coherence, and an illumination-light study system which illuminates an illuminated field of specified shape by said illumination light, In an exposure device which has a relatively scan means to synchronize and to scan a mask and a substrate with which a predetermined pattern was relatively formed to said illuminated field, and carries out scanning exposure of said substrate,

A measuring means which measures information on an angle of divergence of said illumination light,

A control means which controls an exposing condition of said substrate based on information on a measured this angle of divergence,

An exposure device characterized by preparation   .

[Claim 18 In an exposure device which has a light source which generates illumination light which has spatial coherence, an illumination-light study system which illuminates an illuminated field of specified shape by illumination light, and a relatively scan means to synchronize and to scan a mask and a substrate with which a predetermined pattern was relatively formed to said illuminated field, and carries out scanning exposure of said substrate, Said illumination-light study system has a polarization means which divides illumination light from said light source into the 1st illumination light of the 1st polarization component, and the 2nd illumination light of the 2nd polarization component,

An exposure device with which said 1st illumination light and said 2nd illumination light are characterized by shifting illuminance distribution on said mask in said direction of a relatively scan mutually.

[Claim 19 In an exposure method which carries out scanning exposure of said substrate by scanning synchronously a mask and a substrate with which a predetermined pattern was relatively formed to said illuminated field while illuminating an illuminated field of specified shape by illumination light which has spatial coherence,

An exposure method making the same as that of a relative scanning direction of an illuminated field of said specified shape, and said mask the high direction of contrast of a speckle pattern formed in said illuminated field.

[Claim 20 In an exposure method which carries out scanning exposure of said substrate by scanning synchronously a mask and a substrate with which a predetermined pattern was

relatively formed to said illuminated field while illuminating an illuminated field by illumination light which has spatial coherence,

Said illumination light is discharged from a light source with sectional shape which has a longitudinal direction and the transverse direction,

An exposure method characterized by making it in agreement   the transverse direction of sectional shape of said illumination light] with a relative scanning direction of said illuminated field and said mask.

[Claim 21 In an exposure method which carries out scanning exposure of said substrate by scanning synchronously a mask and a substrate with which a predetermined pattern was relatively formed to said illuminated field while illuminating an illuminated field of specified shape by illumination light which has spatial coherence,

An exposure method displacing said speckle pattern in said illuminated field so that influence of a speckle pattern formed in said illuminated field may become small, while said mask and said substrate are moving to said illuminated field during said scanning exposure.

[The amendment 3]

[Document to be Amended Specification

[Item(s) to be Amended 0001

[Method of Amendment]Change

[Proposed Amendment

[0001]

[Industrial Application By this invention's illuminating a rectangle or the illuminated field of circular **, for example by exposing light, and scanning a mask and a sensitized substrate synchronously to the illuminated field, About the exposure method and exposure device of what is called a slit scan exposure system which expose the pattern on a mask on a sensitized substrate one by one, when using a high light of especially spatial coherence as exposing light, it applies, and it is suitable.

[Amendment 4]

[Document to be Amended Specification

[Item(s) to be Amended 0007

[Method of Amendment]Change

[Proposed Amendment

[0007]An object of this invention when using a high light of spatial coherence as exposing light with the exposure method and exposure device of a slit scan exposure system in view of this point is to make illumination unevenness by a speckle pattern as small as possible.

[Amendment 5]

[Document to be Amended Specification

[Item(s) to be Amended 0008

[Method of Amendment]Change

[Proposed Amendment

[0008]

[Means for Solving the Problem As shown, for example in drawing 1 and drawing 2, the 1st exposure device by this invention, A light source (1) which generates illumination light (LB_0) which has spatial coherence, An illumination-light study system (2-14) which illuminates an illuminated field (15) of specified shape by the illumination light, It has a relatively scan means (32, 34, 35, RST, WST) to synchronize and to scan a mask (R) and a substrate (W) with which a predetermined pattern was relatively formed to an illuminated field (15), In an exposure device which carries out scanning exposure of the substrate (W), the high direction (direction H) of spatial coherence of illumination light (LB_0) is made the same as that of an illuminated field (15) of specified shape, and a relative scanning direction (direction SR) with a mask (R).

[Amendment 6]

[Document to be Amended Specification

[Item(s) to be Amended 0009

[Method of Amendment]Change

[Proposed Amendment

[0009]As shown, for example in drawing 1 and drawing 2, the 2nd exposure device by this invention, The pulse light source (1) which generates the pulsed light (LB_0) which has spatial coherence, The illumination-light study system (2-14) which illuminates the illuminated field (15) of specified shape by the pulsed light, It has a relatively scan means (32, 34, 35, RST, WST) to synchronize and to scan the mask (R) and substrate (W) with which the predetermined pattern was relatively formed to the illuminated field (15), In the exposure device which carries out scanning exposure, the substrate (W) The illuminated field (15) of specified shape, and a relative scan speed with a mask (R), According to the pitch of the relative scanning direction (direction SR) of the speckle pattern of the pulsed light in an illuminated field (15), a phase variable means (8, 9) to change the phase of the speckle pattern of the pulsed light in an illuminated field (15) for every pulsed light of the is formed.

[Amendment 7]

[Document to be Amended Specification

[Item(s) to be Amended 0010

[Method of Amendment]Change

[Proposed Amendment

[0010]In this case, it is desirable to establish a spatial coherence detection means (17, 18) to detect the spatial coherence of that pulsed light, and the control means (32) which controls operation of a phase variable means (8, 9) according to the spatial coherence of that pulsed

light detected in this way. Next, the light source in which the 3rd exposure device of this invention generates the illumination light which has spatial coherence, It has an illumination-light study system which illuminates the illuminated field of specified shape by the illumination light, and a relatively scan means to synchronize and to scan the mask and substrate with which the predetermined pattern was relatively formed to the illuminated field, and is characterized by comprising the following in the exposure device which carries out scanning exposure of the substrate:

The displacement means which displaces the speckle pattern of the illumination light formed in the illuminated field in the illuminated field.

The control means which controls the displacement means so that the influence of the speckle pattern formed in the illuminated field is reduced, while the mask and its substrate are moving to the illuminated field during the scanning exposure.

The light source in which the 4th exposure device of this invention generates the illumination light which has spatial coherence, It has an illumination-light study system which illuminates the illuminated field of specified shape by the illumination light, and a relatively scan means to synchronize and to scan the mask and substrate with which the predetermined pattern was relatively formed to the illuminated field, and is characterized by comprising the following in the exposure device which carries out scanning exposure of the substrate:

The measuring means which measures the information on the angle of divergence of the illumination light.

The control means which controls the exposing condition of that substrate based on the information on this measured angle of divergence.

The light source in which the 5th exposure device by this invention generates the illumination light which has spatial coherence, In the exposure device which has an illumination-light study system which illuminates the illuminated field of specified shape by the illumination light, and a relatively scan means to synchronize and to scan the mask and substrate with which the predetermined pattern was relatively formed to the illuminated field, and carries out scanning exposure of the substrate, The illumination-light study system had a polarization means which divides the illumination light from the light source into the 1st illumination light of the 1st polarization component, and the 2nd illumination light of the 2nd polarization component, and the 1st illumination light and its 2nd illumination light are shifted mutually [the illuminance distribution on the mask] in the direction of a relatively scan.Next, while the 1st exposure method by this invention illuminates the illuminated field of specified shape by the illumination light which has spatial coherence, By scanning synchronously the mask and substrate with which the predetermined pattern was relatively formed to the illuminated field, In the exposure method which carries out scanning exposure of the substrate, the high direction of the contrast of the speckle pattern formed in the illuminated field is made the same as that of the relative

scanning direction of the illuminated field and mask of the specified shape. While the 2nd exposure method by this invention illuminates an illuminated field by the illumination light which has spatial coherence, By scanning synchronously the mask and substrate with which the predetermined pattern was relatively formed to the illuminated field, It is discharged from a light source with the sectional shape which has a longitudinal direction and the transverse direction, and is made for the transverse direction of the illumination light of the sectional shape of the illumination light to correspond with the relative scanning direction of the illuminated field and its mask in the exposure method which carries out scanning exposure of the substrate. While the 3rd exposure method by this invention illuminates the illuminated field of specified shape by the illumination light which has spatial coherence, By scanning synchronously the mask and substrate with which the predetermined pattern was relatively formed to the illuminated field, In the exposure method which carries out scanning exposure of the substrate, while the mask and its substrate are moving to the illuminated field during the scanning exposure, The speckle pattern is displaced in the illuminated field so that the influence of the speckle pattern formed in the illuminated field may become small.

[Amendment 8]

[Document to be Amended Specification

[Item(s) to be Amended 0016

[Method of Amendment]Change

[Proposed Amendment

[0016]Thereby, since each irradiation point on a mask (R) is exposed with illumination with a speckle pattern of a phase which is equally divided according to a pulse number and is different called the distribution curves 40, 42, and 43 of drawing 5 (b), an integrated exposure is equalized and the illumination unevenness in the scanning direction on a mask (R) is reduced. Namely, n and m are made into an integer in the arbitrary irradiation points on a mask (R), So that the phase of the scanning direction on the distribution curve 40 may become 0, 2mpi+ (2 pi/n), 4mpi+ (4 pi/n), 6mpi+ (6 pi/n), ..., 2(n-1)mpi+2 (n-1) pi/n, and ... for every pulse radiation, The illumination unevenness of a scanning direction is reduced by controlling operation of a phase variable means (8, 9).

[Amendment 9]

[Document to be Amended Specification

[Item(s) to be Amended 0018

[Method of Amendment]Change

[Proposed Amendment

[0018]

[Example Hereafter, with reference to drawings, it explains per example of this invention. This example applies this invention to the projection aligner of the slit scan exposure system which

uses a pulse oscillation type laser light source as a light source of exposing light. Drawing 1 shows the optical system of the projection aligner of this example, and laser beam LB_0 of the far ultraviolet region (wavelength is 248 nm) ejected from the excimer laser 1 in this drawing 1, It enters into the beam shaping optical system 2 which contains a cylindrical lens via the purple external use reflective mirror M1, M2, M3, and M4. The sectional shape of laser beam LB_0 ejected from the excimer laser 1 is a long and slender rectangle whose horizontal (the direction of H) width is quite narrower than vertical (the direction of V) width.

In the beam shaping optical system 2, the horizontal width of laser beam LB_0 is expanded and the laser beam LB of the sectional shape of the almost same aspect ratio as the aspect ratio of the slit shape below-mentioned illuminated field 15 is ejected.

[Amendment 10]

[Document to be Amended Specification

[Item(s) to be Amended 0019

[Method of Amendment]Change

[Proposed Amendment

[0019]As drawing 3 shows the composition of the beam shaping optical system 2 and shows it to this drawing 3, entering laser beam LB_0, pass the cylindrical lens 38 of focal distance f_1, and the cylindrical lens 39 of focal distance f_2 ($f_2 > f_1$) -- the horizontal width of sectional shape is expanded f_2/f_1 twice. If the spread angle of entering laser beam LB_0 is made into $theta_1$, spread angle $theta_2$ of the laser beam LB ejected will decrease to f_1/f_2 of spread angle $theta_1$. Generally, since the spatial coherence of light flux is so high that a spread angle is small, the spatial coherence of the horizontal direction (the direction of H) of the laser beam LB ejected is raised rather than entering laser beam LB_0.

[Amendment 11]

[Document to be Amended Specification

[Item(s) to be Amended 0025

[Method of Amendment]Change

[Proposed Amendment

[0025]A part of laser beam ejected from the front mirror 22 is led to the wavelength detectors (spectroscope etc.) 31 via the beam splitter 30, and the wavelength which detected and detected the wavelength of the laser beam with the wavelength detector 31 is transmitted to the wavelength adjustment actuator 27. The wavelength adjustment actuator 27 changes the angle of inclination of the diffraction grating 25 so that a difference with the absolute wavelengths defined beforehand may come in a standard according to the wavelength

detected with the wavelength detector 31. The signal according to the beam angle of divergence which processes the imaging signal from the two-dimensional image sensor 17 by the image processing system 18, and is detected. (The signal according to the size of the beam spot specifically made on the two-dimensional image sensor 17) is fed back to the actuator 28 of the rear mirror 23 of the excimer laser 1, and it is sent also to the main control unit 32 which controls operation of the whole device. The actuator 28 changes the angle of inclination of the rear mirror 23, when the value of the angle of divergence of the beam surveyed to the value defined beforehand has separated more than tolerance level.

[Amendment 12]

[Document to be Amended Specification

[Item(s) to be Amended 0043

[Method of Amendment]Change

[Proposed Amendment

[0043]

[Effect of the Invention According to this invention, since the high direction of the contrast of the interference fringe of a speckle pattern is reduced by relative scan with an illuminated field and a mask (substrate) in accordance with a scanning direction as for the illumination unevenness of the scanning direction, there is an advantage whose illumination unevenness by a speckle pattern becomes small.

[Amendment 13]

[Document to be Amended Specification

[Item(s) to be Amended 0044

[Method of Amendment]Change

[Proposed Amendment

[0044]While carrying out the relatively scan of a mask and the substrate to the illuminated field, the speckle pattern is made to be displaced in an illuminated field in this invention. therefore, the mitigation and the interval by relative scan with an illuminated field and a mask (substrate) make very small influence of the illumination unevenness by a speckle pattern -- things can be carried out.

[Amendment 14]

[Document to be Amended Specification

[Item(s) to be Amended 0045

[Method of Amendment]Change

[Proposed Amendment

[0045]According to the relative scan speed of an illuminated field and a mask (substrate), and the pitch of the relative scanning direction of the speckle pattern of the pulsed light in the

illuminated field, especially, By changing the phase of the speckle pattern of the pulsed light in an illuminated field for every pulsed light, illumination unevenness by a speckle pattern can be made smaller.

[Translation done.]

(51)Int.Cl.^{5}	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｌ　21/027				
Ｇ０３Ｂ　27/32	Ｆ	8102−2K		
Ｇ０３Ｆ　7/20	521	7316−2H		
		7352−4M	Ｈ０１Ｌ　21/ 30　　　311　L	
		7352−4M	311　S	

審査請求　未請求　請求項の数3　ＯＬ　（全 9 頁）

(71)出願人　000004112
　　　　株式会社ニコン
　　　　東京都千代田区丸の内3丁目2番3号
(72)発明者　中島　利治
　　　　東京都千代田区丸の内3丁目2番3号　株
　　　　式会社ニコン内
(72)発明者　濱谷　正人
　　　　東京都千代田区丸の内3丁目2番3号　株
　　　　式会社ニコン内
(74)代理人　弁理士　大森　聡

(54)【発明の名称】　露光装置

(57)【要約】
【目的】　スリットスキャン露光方式で空間コヒーレンスの高い光を露光光として使用する場合に、スペックルパターンによる照度むらを小さくする。
【構成】　照明領域１５に対してレチクルＲを走査方向ＳＲに走査し、照明領域１５と共役な露光領域１６に対してウエハＷを走査方向ＳＷに走査し、レチクルＲのパターンを逐次ウエハＷ上に露光する。エキシマレーザ光源１から射出されるレーザビームＬＢ。の空間コヒーレンスは水平方向（Ｈ方向）に高いため、その水平方向と照明領域１５の走査方向ＳＲとを共役にして、空間コヒーレンスの高い方を走査方向ＳＲとする。
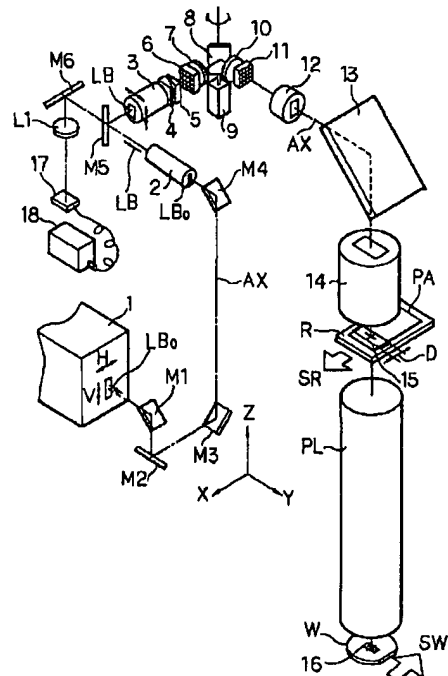
【特許請求の範囲】

【請求項1】 所定の空間コヒーレンスを有する照明光を発生する光源と、前記照明光で所定形状の照明領域を照明する照明光学系と、前記照明領域に対して相対的に転写用のパターンが形成されたマスク及び感光性の基板を同期して走査する相対走査手段とを有し、前記マスクのパターンを逐次前記基板上に露光する露光装置において、

前記照明光の空間コヒーレンスの高い方向を前記所定形状の照明領域と前記マスクとの相対的な走査方向と同一にしたことを特徴とする露光装置。

【請求項2】 所定の空間コヒーレンスを有するパルス光を発生するパルス光源と、前記パルス光で所定形状の照明領域を照明する照明光学系と、前記照明領域に対して相対的に転写用のパターンが形成されたマスク及び感光性の基板を同期して走査する相対走査手段とを有し、前記マスクのパターンを逐次前記基板上に露光する露光装置において、

前記所定形状の照明領域と前記マスクとの相対的な走査速度と、前記照明領域での前記パルス光のスペックルパターンの前記相対的な走査方向のピッチとに応じて、前記照明領域での前記パルス光のスペックルパターンの位相を前記パルス光毎に変化させる位相可変手段を設けたことを特徴とする露光装置。

【請求項3】 前記パルス光の空間コヒーレンスを検出する空間コヒーレンス検出手段と、該検出された前記パルス光の空間コヒーレンスに応じて前記位相可変手段の動作を制御する制御手段と、を設けたことを特徴とする請求項2記載の露光装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】 本発明は、例えば露光光で矩形又は円弧状等の照明領域を照明し、その照明領域に対してマスク及び感光基板を同期して走査することにより、マスク上のパターンを逐次感光基板上に露光する所謂スリットスキャン露光方式の露光装置に関し、特に空間コヒーレンスの高い光を露光光として用いる場合に適用して好適なものである。

【0002】

【従来の技術】 従来より、半導体素子、液晶表示素子又は薄膜磁気ヘッド等をフォトリソグラフィー技術を用いて製造する際に、フォトマスク又はレチクル（以下、「レチクル」と総称する）のパターンを投影光学系を介して、フォトレジスト等が塗布された基板（ウエハ又はガラスプレート等）上に露光する投影露光装置が使用されている。斯かる投影露光装置では、露光光を短波長化して解像度を向上させるために、ＫｒＦエキシマレーザ若しくはＡｒＦエキシマレーザのようなエキシマレーザ光、又はアルゴンレーザの高調波のような紫外域のレーザ光が露光光として使用されるようになって来ている。

【0003】 ところが、レーザ光は空間コヒーレンス（可干渉性）が高く、照明光学系を通過する間にスペックルパターンと呼ばれる干渉縞が生じ、これがレチクル及び基板上での照度むらになるという問題がある。そこで、従来の通常のステッパーのような一括露光方式の投影露光装置で、レーザ光を露光光として使用する場合には、スペックルパターンによる照度むらを減少させるために、照明光学系中のフライアイレンズ（オプティカル・インテグレータ）の前に振動ミラーを配置していた。そして、1度の露光の間に、そのオプティカル・インテグレータに入射するレーザ光をその振動ミラーで走査することによって、レチクル及び基板上に生じるスペックルパターン（干渉縞）の位相を変えながら露光を行い、基板上の各ショット領域内の全面での露光量が均一になるようにしていた。この場合、一回の露光の間に、干渉縞の位相が2π変化するように振動ミラーを振ることにより、基板上の露光量の分布のコントラストが最小になる。

【0004】

【発明が解決しようとする課題】 最近は、半導体素子の1個のチップサイズが大型化する傾向にあり、投影露光装置においては、レチクル上のより大きな面積のパターンを基板上に露光する大面積化が求められている。斯かる被転写パターンの大面積化及び投影光学系の露光フィールドの制限に応えるために、例えば矩形、円弧状又は6角形等の照明領域（これを「スリット状の照明領域」という）に対してレチクル及び感光性の基板を同期して走査することにより、レチクル上のパターンを逐次基板上に露光する所謂スリットスキャン露光方式の投影露光装置が開発されている。このようなスリットスキャン露光方式の投影露光装置でも、露光光としてレーザ光のような空間コヒーレンスの高い光を使用する場合には、スペックルパターンによる照度むらを低減させる必要がある。

【0005】 しかしながら、スリットスキャン露光方式では、レチクル及び基板が走査されているためスペックルパターンの出現する位相が時間変化する。従って先ず、レチクル及び基板の走査方向が問題となる。次に一括露光方式のときに用いた振動ミラーを併用する場合、その走査方向並びにレチクル及び基板の走査速度に合わせて振動ミラーをどのように制御するかが問題になる。

【0006】 例えば、図7（a）〜（d）はスリット状の照明領域51に対してX方向（走査方向ＳＲ）にレチクルＲを走査する状態を示し、図7（a）の状態から図7（d）の状態にかけて、次第にレチクルＲのパターン領域ＰＡが相対的に照明領域51により走査される。従って、レチクルＲのパターン領域ＰＡではX方向に対しては実質的に走査が行われているが、X方向に垂直なY方向（非走査方向）に対しては静止状態であるため、走査方向と非走査方向とでスペックルパターンの影響が異

3

なっている。

【0007】本発明は斯かる点に鑑み、スリットスキャン露光方式の露光装置で空間コヒーレンスの高い光を露光光として使用する場合に、スペックルパターンによる照度むらをできるだけ小さくすることを目的とする。

【0008】

【課題を解決するための手段】本発明による第1の露光装置は、例えば図1及び図2に示すように、所定の空間コヒーレンスを有する照明光（ＬＢ０）を発生する光源（1）と、その照明光で所定形状の照明領域（15）を照明する照明光学系（2～14）と、照明領域（15）に対して相対的に転写用のパターンが形成されたマスク（Ｒ）及び感光性の基板（Ｗ）を同期して走査する相対走査手段（32，34，35，ＲＳＴ，ＷＳＴ）とを有し、マスク（Ｒ）のパターンを逐次基板（Ｗ）上に露光する露光装置において、照明光（ＬＢ０）の空間コヒーレンスの高い方向（方向Ｈ）を所定形状の照明領域（15）とマスク（Ｒ）との相対的な走査方向（方向ＳＲ）と同一にしたものである。

【0009】また、本発明による第2の露光装置は、例えば図1及び図2に示すように、所定の空間コヒーレンスを有するパルス光（ＬＢ０）を発生するパルス光源（1）と、そのパルス光で所定形状の照明領域（15）を照明する照明光学系（2～14）と、照明領域（15）に対して相対的に転写用のパターンが形成されたマスク（Ｒ）及び感光性の基板（Ｗ）を同期して走査する相対走査手段（32，34，35，ＲＳＴ，ＷＳＴ）とを有し、マスク（Ｒ）のパターンを逐次基板（Ｗ）上に露光する露光装置において、所定形状の照明領域（15）とマスク（Ｒ）との相対的な走査速度と、照明領域（15）でのそのパルス光のスペックルパターンのその相対的な走査方向（方向ＳＲ）のピッチとに応じて、照明領域（15）でのそのパルス光のスペックルパターンの位相をそのパルス光毎に変化させる位相可変手段（8，9）を設けたものである。

【0010】この場合、そのパルス光の空間コヒーレンスを検出する空間コヒーレンス検出手段（17，18）と、このように検出されたそのパルス光の空間コヒーレンスに応じて位相可変手段（8，9）の動作を制御する制御手段（32）とを設けることが望ましい。

【0011】

【作用】斯かる本発明の第1の露光装置によれば、予め照明光（ＬＢ０）の光束に垂直な面内で空間コヒーレンス（可干渉性の程度）の高い方向を計測しておき、所定形状の照明領域（15）においてマスク（Ｒ）との相対的な走査の方向（ＳＲ方向）に、その空間コヒーレンスの高い方向を合わせている。従って、例えば図4に示すように、照明領域（15）上に形成される照明光によるスペックルパターンの走査方向（ＳＲ方向）の照度分布は、分布曲線40のように所定ピッチで比較的大きい振

4

幅で変動する。また、その照明領域（15）上のスペックルパターンの非走査方向（Ｙ方向）の照度分布は、分布曲線41のように比較的平坦である。この場合、走査方向ではマスク（Ｒ）上の各点の照度分布は、それぞれ分布曲線40のように変化して、実質的に振動ミラーで走査した場合と同様になるため、照度むらは少ない。また、非走査方向ではもともと照度むらは少ないため、マスク（Ｒ）及び基板（Ｗ）の全面で照度むらが少なくなる。

【0012】また、本発明の第2の露光装置によれば、照明光としてパルス光が使用されている。パルス光が例えば遠紫外域のエキシマレーザ光（波長が例えば248ｎｍ）である場合、光学系での色収差を消すことが容易ではないため、パルス光源（1）では回折格子及びスリット等を使用することによりスペクトル線幅を狭帯化したパルス光を発生する。そのため、図1において、光源（1）から射出されるパルス光（ＬＢ０）は、水平方向（Ｈ方向）で空間コヒーレンスが高く且つビーム幅が狭くなっているが、垂直方向（Ｖ方向）では空間コヒーレンスが低く且つビーム幅が広くなっている。従って、本発明では光源（1）から射出されるパルス光（ＬＢ０）の水平方向を、マスク（Ｒ）上のスリット状の照明領域（15）の走査方向に設定する。

【0013】この場合、そのパルス光（ＬＢ０）の水平方向の幅と垂直方向の幅との比は、一般に通常のスリット状の照明領域（15）の走査方向の幅と非走査方向の幅との比よりも小さいため、例えば図3に示すような、2枚のシリンドリカルレンズ38及び39を用いて、そのパルス光（ＬＢ０）の水平方向の幅を広げる必要がある。このとき、入射するパルス光（ＬＢ０）の拡がり角をθ_1、前段のシリンドリカルレンズ38の焦点距離をf_1、後段のシリンドリカルレンズ39の焦点距離をf_2とすると、シリンドリカルレンズ39から射出されるパルス光（ＬＢ）の拡がり角θ_2は、次のようになる。

【0014】$\theta_2 = (f_1 / f_2) \theta_1$　　(1)

従って、水平方向のビーム幅を拡げるために、$f_1 < f_2$とすると、次のようになり、射出されるパルス光（ＬＢ）の拡がり角θ_2は小さくなる。

$\theta_1 > \theta_2$　　(2)

従って、ビーム幅を水平方向に拡げると、図4に示すように照明領域（15）の走査方向（ＳＲ方向）での空間コヒーレンスは更に高くなる。そのため、走査方向にはコントラストの高いスペックルパターンが形成される。これに対して非走査方向のスペックルパターンのコントラストは低いため、非走査方向では照度むらは少ない。

【0015】その照明領域（15）の走査方向の照度分布は例えば図5（ａ）の分布曲線40のようになる。マスク及び基板の走査方向をこの方向に選べば、走査による位相ずれによって図5（ｂ）のように様々な位相の波の畳重になるので、積算効果によってスペックルの軽減

が見込まれる。但し、何等かの制御を行わない場合、走査速度によっては、パルス発光のタイミングとスペックルパターンの位相がほぼ一致する形になり、マスク（R）上の或る照射点では、例えば図5（a）の位置40C，40F，…の順に露光が行われ、別の照射点では位置40B，40E，…の順に露光が行われて、積算効果が見込めず、照度むらが軽減されない可能性もある。これを避けるために、図5（a）の位置40C，40F，40Iで、パルス発光が行われるような走査速度のときは、振動ミラーを走査させて、位置40Fで発光するときはδA、位置40Iで発光するときはδBだけ横ずれさせるような走査制御をする。

【0016】これによりマスク（R）上の各照射点は、図5（b）の分布曲線40，42，43という、パルス数に応じて等分されて、異なる位相のスッペクルパターンをもつ照度で露光されるため、積算露光量は平均化され、マスク（R）上の走査方向での照度むらは低減される。即ち、マスク（R）上の任意の照射点において、n，mを整数として、パルス発光毎に分布曲線40上の走査方向の位相が0，2mπ＋（2π／n），4mπ＋（4π／n），6mπ＋（6π／n），・・・，2（n−1）mπ＋2（n−1）π／n，・・・となるように、位相可変手段（8，9）の動作を制御することにより、走査方向の照度むらが低減される。

【0017】また、そのパルス光の空間コヒーレンスを検出する空間コヒーレンス検出手段（17，18）と、このように検出されたそのパルス光の空間コヒーレンスに応じて位相可変手段（8，9）の動作を制御する制御手段（32）とを設けた場合には、検出された空間コヒーレンスに応じて、マスク（R）及び基板（W）上でのスペックルパターンに起因する照度むらが最小になるように、位相可変手段（8，9）の動作を制御する。

【0018】
【実施例】以下、本発明による露光装置の一実施例につき図面を参照して説明する。本実施例は、露光光の光源としてパルス発振型のレーザ光源を使用したスリットスキャン露光方式の投影露光装置に本発明を適用したものである。図1は本例の投影露光装置の光学系を示し、この図1において、エキシマレーザ光源1から射出された遠紫外域（波長は例えば248nm）のレーザビームLB₀は、紫外用反射ミラーM1，M2，M3及びM4を介してシリンドリカルレンズを含むビーム整形光学系2に入射する。エキシマレーザ光源1から射出されたレーザビームLB₀の断面形状は、水平方向（H方向）の幅が垂直方向（V方向）の幅よりかなり狭い細長い矩形であり、ビーム整形光学系2では、レーザビームLB₀の水平方向の幅を拡げ、後述のスリット状の照明領域15の縦横比とほぼ同じ縦横比の断面形状のレーザビームLBを射出する。

【0019】図3は、ビーム整形光学系2の構成を示

し、この図3に示すように、入射するレーザビームLB₀は、焦点距離f₁のシリンドリカルレンズ38及び焦点距離f₂（f₂＞f₁）のシリンドリカルレンズ39を経て、断面形状の水平方向の幅がf₂／f₁倍に拡大される。入射するレーザビームLB0の拡がり角をθ₁とすると、射出されるレーザビームLBの拡がり角θ₂は、拡がり角θ₁のf₁／f₂に減少している。一般に、光束の空間コヒーレンスは拡がり角が小さい程高いため、射出されるレーザビームLBの水平方向（H方向）の空間コヒーレンスは、入射するレーザビームLB₀よりも高められている。

【0020】図1に戻り、ビーム整形光学系2から射出されたレーザビームLBは、紫外用反射ミラーM5で折り曲げられてビームエクスパンダー（又はズームレンズ）3に入射し、所定の断面寸法にまで断面形状が拡大される。ビームエクスパンダー3から射出された平行なレーザビームLBは、偏光手段としての水晶プリズム4に入射し、2つの直交する偏光成分に分離される。このように分離された2つの偏光成分は、光路補正用の石英ガラスプリズム5に入射し、ビームの進行方向が補正される。その後、2つの偏光成分のレーザビームは、1段目のフライアイレンズ6及びリレーレンズ7を経て、振動ミラー8で折り曲げられる。振動ミラー8は駆動装置9により、水平面上の所定の角度範囲内でレーザビームを適切な制御方法で走査する。

【0021】振動ミラー8で走査されるレーザビームが、リレーレンズ10を経て2段目のフライアイレンズ11に入射し、その射出側の焦点面に多数の3次光源（スポット光）が結像され、これら多数の3次光源からのレーザビームが、更に集光レンズ12によって集光されミラー13で曲げ折られて、メインコンデンサーレンズ14に入射する。多数の3次光源からのレーザビームはメインコンデンサーレンズ14によって、レチクルR上の短辺方向の幅がDの長方形の照明領域15に重量して照射される。その照明領域15内のパターン像が投影光学系PLを介してウエハW上の長方形の露光領域16内に結像投影される。

【0022】この場合、投影光学系PLの光軸に平行にZ軸を取り、その光軸に垂直なXY平面内のX軸を長方形の照明領域15の短辺方向に取る。そして、本例では、投影光学系PLの投影倍率をβとして、照明領域15に対してレチクルRをX方向（これを「走査方向SR」とする）に速度Vで走査するのと同期して、ウエハWを−X方向（これを「走査方向SW」とする）に速度β・Vで走査することにより、レチクルRのパターン領域PA内の回路パターン像が逐次ウエハWのショット領域に投影露光される。

【0023】図1において、エキシマレーザ光の空間コヒーレンスを調べるために、集光レンズL1を紫外用反射ミラーM5の後ろに設置し、紫外用反射ミラーM5で

7

の漏れ光を集光レンズL1の後側焦点位置に集光させ、その焦点位置に設置したCCDよりなる2次元撮像素子17で2次元的に分布する漏れ光を受光する。そして、2次元撮像素子17からの撮像信号を画像処理系18で処理することで、レーザビームの発散角を測定するようにした。レーザビームの発散角は空間コヒーレンスに対して反比例の関係にあるため、その測定した発散角により、照明領域15上での走査方向SR及び非走査方向の空間コヒーレンスを算出することができる。

【0024】図2は、図1の投影露光装置の制御系を示し、この図2において、エキシマレーザ光源1内には、レーザ発振の媒体となるガスや発振トリガ用の電極を封入したレーザチューブ21、共振器を構成する所定の反射率（100％未満）を持ったフロントミラー22、その共振器のリアミラー23、波長選択用の開口板29、波長選択及び波長狭帯化用のプリズム24、及び反射型回折格子25等が、光学素子として設けられている。更に、エキシマレーザ光源1には、レーザチューブ21内の電極に高電圧を印加して発振を行わせるための発振制御部26、発振されるレーザビームの絶対波長を常に一定にするために、回折格子25の傾斜角を調整する波長調整駆動部27、及びリアミラー23の傾きを調整するための駆動部28等が設けられている。

【0025】また、フロントミラー22から射出されたレーザビームの一部を、ビームスプリッター30を介して波長検出器（分光器等）3に導き、波長検出器31でレーザビームの波長を検出し、検出した波長を波長調整駆動部27に伝達する。波長調整駆動部27は、波長検出器31で検出された波長に応じて、予め定められた絶対波長との差が規格内になるように回折格子25の傾斜角を変化させる。また、2次元撮像素子17からの撮像信号を画像処理系18で処理して検知されるビーム発散角に応じた信号（具体的には、2次元撮像素子17上に作られたビームスポットの大きさに応じた信号）は、エキシマレーザ光源1のリアミラー23の駆動部28へフィードバックされると共に、装置全体の動作を制御する主制御装置32へも送られる。駆動部28は予め定められた値に対して実測されたビームの発散角の値が、許容範囲以上に外れているときは、リアミラー23の傾斜角を変化させる。

【0026】また、図1のレチクルRの位置決め及び走査は図2のレチクルステージRSTによって行われ、ウエハWの位置決め及び走査は図2のウエハステージWSTによって行われる。レチクルステージRSTは、1チップのパターンが描かれたレチクルRの照射範囲を順次変えるために、レチクルRの走査を行う。ウエハステージWSTは、ウエハW上の複数のショット領域の夫々に対してレチクルRのパターン像が露光されるように、X方向及びY方向にステップ・アンド・リピート方式でウエハWを移動させる機能と、レチクルRの照射範囲に応

8

じてレチクルRの走査に同期してウエハWを走査する機能とを合わせ持つ。

【0027】主制御装置32は、発振制御部26を介してエキシマレーザ光源1の発振を制御し、ウエハステージ制御系34及びレチクルステージ制御系35を介してそれぞれウエハステージWST及びレチクルステージRSTの動作を制御する。そして、主制御装置32は、駆動装置9を介して振動ミラー8の振動の振幅及び周期等を制御する。また、主制御装置32には、入力装置としてのキーボード36、座標入力装置（所謂マウス）37や出力装置としての表示部（CRTディスプレイ、メータ等）33等が接続されている。キーボード36及び座標入力装置37は、或るウエハの露光処理にあたって1ショット領域当り何パルスで露光するかを予め指定することの他に、種々のシーケンス設定やパラメータ設定のために使われる。

【0028】また、主制御装置32は、予備発振中のエキシマレーザ光源1からのレーザビームのビーム発散角の情報を画像処理系18から受け取り、スループットを下げないで、スペックルパターンを最も小さくするように最適化された発振周波数、及びウエハW上の1つのショット領域に照射されるレーザビームのパルス数を決定して、発振制御部26に指令を発する。並行して主制御装置32は、振動ミラー8の振動周期、振幅、及び位相を決定して駆動装置9に指令を発すると共に、レチクルステージ制御系35およびウエハステージ制御系34には、最適な走査速度を決定して指令を出す。

【0029】次に、本例でレチクルR及びウエハW上の照度むらを低減させるための構成につき説明する。先ず、本例では、図1においてエキシマレーザ光源1から射出されるレーザビームLB。の空間コヒーレンスは水平方向（H方向）に高くなっている。そこで、そのレーザビームLB。の空間コヒーレンスの高い方向が照明領域15の短辺方向、即ち走査方向SRになるように、照明光学系を構成する。これにより、レチクルR上の照明領域15上に形成されるレーザビームのスペックルパターンは、走査方向SRのコントラストが高く、非走査方向（Y方向）のコントラストが低くなっている。

【0030】図1のレチクルR上及びウエハW上に生成されるスペックルパターンには、フライアイレンズ6及び11のレンズエレメントの配列に対応した周期的な成分が含まれており、この干渉パターンのコントラストは、レチクルR上のX方向に高くなる。本例では、スペックルパターンのコントラストを低減させるために、レーザビームLBを、偏光手段としての水晶プリズム4により所定の角度をなす2つの偏光成分のレーザビームに分離してレチクルRを照明している。その2つの偏光成分の内、第1の偏光成分のレーザビームによる照明領域15の走査方向（X方向）の照度分布I（X）（相対値）は、図6（a）の分布曲線40のように、所定ビッ

9

チで周期的に変化している。これに対して、第2の偏光成分のレーザビームによる照度分布Ｉ（Ｘ）は、分布曲線44で示すように分布曲線40に対してＸ方向に半ピッチだけずれている。これにより全体の照度分布Ｉ（Ｘ）は、図6（ｂ）の分布曲線45となり、照度分布の変動の振幅は低減される。

【0031】図4は本例のレチクルＲ上の照明領域15の照度分布を示し、レチクルＲ上には図4（ａ）に示すように走査方向ＳＲ（Ｘ方向）の幅Ｄの照明領域15が形成されている。そして、照明領域15のＸ方向の照度分布Ｉ（Ｘ）は、図4（ｂ）の分布曲線40のように所定ピッチで比較的大きな振幅で変化し、照明領域15のＹ方向の照度分布Ｉ（Ｙ）は、図4（ｃ）の分布曲線41のようにほぼ平坦である。従って、非走査方向であるＹ方向での照度むらは小さくなっている。また、本例では、Ｘ方向での照度むらを、照明領域15に対するレチクルＲの走査及び図1の振動ミラー8によるレーザビームの走査により解消する。

【0032】図5（ａ）は、その照明領域15での1パルス光当りの走査方向（Ｘ方向）の照度分布Ｉ（Ｘ）に対応する分布曲線40を示し、原点からＸ座標がＤまでの領域が図4（ａ）の照明領域15の内部である。また、照明領域15に対してレチクルＲがＸ方向に走査されると、レチクルＲ上の各照射点が図5（ａ）（図5（ｂ）も同様）のＸ軸に沿って移動していくものとする。

【0033】本例では、パルス発光が行われ、分布曲線40のピッチをＰＸ、1パルスのエネルギー密度及びレジスト感度から求められる必要パルス数をｎとするとき、ｎ回のパルス発光で、0，ＰＸ／ｎ，2ＰＸ／ｎ，・・・，（ｎ−1）ＰＸ／ｎの各位置にピークを持つ分布曲線が得られるような走査速度（0，ＰＸ／ｎ，2ＰＸ／ｎ，・・・，（ｎ−1）ＰＸ／ｎの順にピークをもつ分布曲線が出現する必要はない。ｎ回のパルス発光で、各々の位置にピークを持つ分布曲線が全て得られればよい。また、ｎが充分に大きくて、ピッチＰＸをｎ／2，ｎ／3，・・・等分した位置にピークを持つ分布曲線が得られればよい場合もある。）が、予め決定されている速度（照射領域Ｄを必要パルス数ｎで割ってレーザーの発振周波数ｆを掛けた値Ｖ＝（Ｄ／ｎ）ｆ）と一致する場合、図1の振動ミラー8を走査させるまでもなく、レチクルＲ上及びウエハＷ上での照度むらは最も効率よく軽減される。

【0034】例えば、必要パルス数が3の場合には、1パルス毎にレチクルＲはＸ方向にＤ／3だけ移動する。従って、図5（ａ）に示すように、レチクルＲ上の或る照射点（Ｘ＝0）では、間隔Ｄ／3の位置40Ａ，40Ｅ，40Ｉ，…の順に露光が行われ、Ｘ方向の露光量分布を見ると、図5（ｂ）の分布曲線40，42，43のパルスの重ね合わせとなるため、積算露光量の光量むら

10

は、極めて小さくなる。レチクルＲが1パルス毎に移動する距離は、照明領域15の走査方向の幅Ｄの整数分の1に予め設定されている。

【0035】但し、レチクルＲ及びウエハＷの走査速度は後述のようにウエハＷ上での適正露光量等により決定されるため、必ずしも前記の条件が満足されない場合がある。このような場合には、図1の振動ミラー8を走査して、0，ＰＸ／ｎ，2ＰＸ／ｎ，・・・，（ｎ−1）ＰＸ／ｎの位置にピークをもつ分布曲線が得られるようにする必要がある。

【0036】具体的に必要パルス数が4の場合には、1パルス毎にレチクルＲは、Ｘ方向にＤ／4だけ移動する。従って、図5（ａ）に示すようにレチクルＲ上の或る照射点（Ｘ＝0）では、間隔がＤ／4の位置40Ａ，40Ｄ，40Ｇ，40Ｋ・・・の順に露光が行われ、別の或る点、Ｘ＝0の位置からＤ／6だけ離れた点では、位置40Ｃ，40Ｆ，40Ｉ，40Ｌの順に露光が行われるため、Ｘ方向の積算露光量の分布は、分布曲線40の重ね合わせとなり、光量むらの軽減は全くされない。そこで振動ミラー8を走査させる。例えば、位置40Ｆでの露光のときはＰＸ／4，位置40ＩのときはＰＸ／2，位置40Ｌのときは3ＰＸ／4だけ振動ミラー8の走査によって位相を変えると、図5（ｃ）のように異なる4種類の位相の波の重畳となり、照度むらが極めて小さくなる。図5（ｃ）で、分布曲線46，47，48は、分布曲線40から振動ミラー8によってそれぞれ位相をＰＸ／4，ＰＸ／2，3ＰＸ／4だけ変えたものである。

【0037】次に、レチクルＲ及びウエハＷの走査速度につき説明する。先ずウエハＷの走査速度は、ウエハＷに与える適正露光量（これはウエハＷ上に塗布されているレジストの感度により定まる）と、パルス毎のエネルギー量とによって決定される。エキシマレーザ光源1のような光源の場合、パルス毎に放出されるエネルギー量が異なるので、照明光学系の中で減光して、パルス数を増やして露光することによって、その積算効果でウエハＷに与える露光量のばらつきが少なくなるように、パルス毎のエネルギー量は決定される。

【0038】ウエハに与える適正露光量をＥ、パルス毎のエネルギー量（平均エネルギー量）をE_pとすると、露光パルス数はE/E_pで表され、レチクルＲ上で一度に照明される範囲の走査方向の長さ（即ち照明領域15の走査方向の幅）はＤであるため、1パルス毎のレチクルＲの移動量は（E_p／Ｅ）Ｄとなり、エキシマレーザ光源1の発振周波数がｆ［Ｈｚ］のとき、レチクルＲの走査速度Ｖは、次式の値に設定される。

【0039】Ｖ＝（E_p／Ｅ）ｆ・Ｄ　　　（3）

なお、上述実施例では照明領域15の非走査方向（図4のＹ方向）へのスペックルパターンの走査は行っていなかったが、非走査方向の照度むらをより軽減するために

11

は、例えば図1において振動ミラー8を垂直方向へ振ることにより、非走査方向へもスペックルパターンの走査を行うことが望ましい。

【0040】また、図4において、走査方向SR（X方向）と非走査方向（Y方向）との両方にスペックルパターンを振動させるためには、X方向とY方向とに交差する方向にスペックルパターンを振動させても良い。

【0041】なお、空間コヒーレンスが高い方向とスキャン方向とを一致させる方法には次のような手法もある。

①露光装置本体側でレチクル、ウエハをX、Y両方向にスキャン可能に構成しておけば、本体とレーザ光源とを接続させた後であっても、コヒーレンスが高い方向をスキャン方向とするだけでよい。このとき、この決定されたスキャン方向がレチクル上の照明領域の短手方向となるように、例えばレチクルブラインドで照明領域の形状を設定する必要がある。

②レーザ光源からのレーザ光の空間コヒーレンスの高い方向が、スキャン方向と一致するように露光装置の照明光学系に入射するレーザビームのコヒーレンスの高い方向を、例えば複数枚のミラーによって調整すれば良い。但しフライアイレンズ等の調整を行う必要があることもある。一般的にはコヒーレンスの高い方向を考慮して装置を組むことが望ましい。

【0042】なお、本発明は上述実施例に限定されず、例えば露光光としてYAGレーザーの高調波よりなるレーザ光を用いる場合や、露光光として水銀ランプのi線のような連続光を使用する場合など、本発明の要旨を逸脱しない範囲で種々の構成を取り得ることは勿論である。

【0043】
【発明の効果】本発明の第1の露光装置によれば、スッベクルパターンの干渉縞のコントラストの高い方向が走査方向に一致し、その走査方向の照度むらは照明領域とマスク（基板）との相対的な走査で軽減されるため、スペックルパターンによる照度むらが小さくなる利点がある。

【0044】また、第2の露光装置によれば、照明領域とマスクとの相対的な走査速度と、その照明領域でのパルス光のスペックルパターンの相対的な走査方向のピッ

12

チとに応じて、照明領域でのパルス光のスペックルパターンの位相をパルス光毎に変化させることができるため、スペックルパターンによる照度むらを小さくできる利点がある。

【0045】また、パルス光の空間コヒーレンスを検出する空間コヒーレンス検出手段と、このように検出されたパルス光の空間コヒーレンスに応じて位相可変手段の動作を制御する制御手段とを設けた場合には、特にスペックルパターンによる照度むらを小さくできる。

【図面の簡単な説明】
【図1】本発明の一実施例の投影露光装置を示す斜視図である。

【図2】実施例の投影露光装置の制御系を示すブロック図である。

【図3】図1のビーム整形光学系2の一例を示す構成図である。

【図4】レチクルR上の照明領域15の照度分布を示す斜視図である。

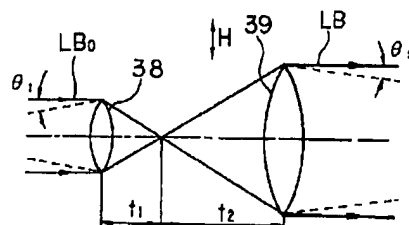【図5】（a）はレチクルR上の照明領域15の走査方向の照度分布を示す図、（b）及び（c）はそれぞれスペックルパターンを振動させる場合の照明領域15の走査方向の照度分布を示す図である。

【図6】（a）は2方向からのレーザビームで照明領域15を照明する場合の照明領域15の2つの照度分布を示す図、（b）は図6（a）の2つの照度分布の和の照度分布を示す図である。
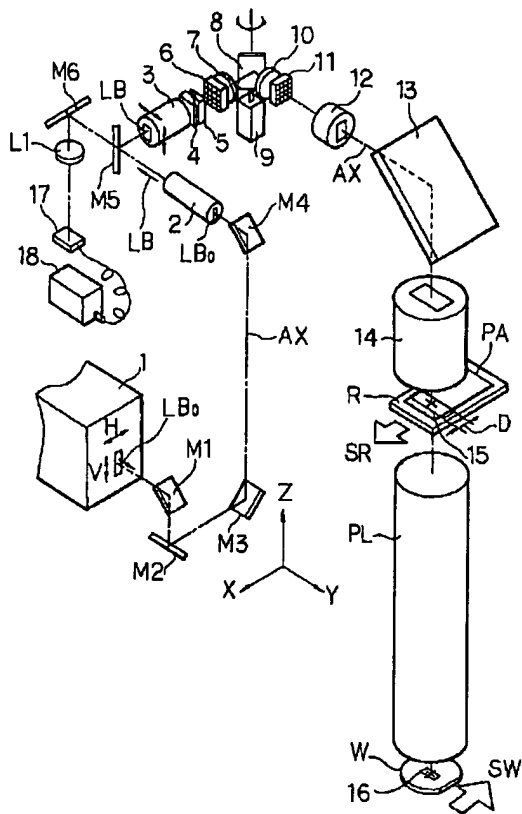
【図7】スリット状の照明領域に対するレチクルの走査の様子を示す図である。

【符号の説明】
1　エキシマレーザ光源
6，7　フライアイレンズ
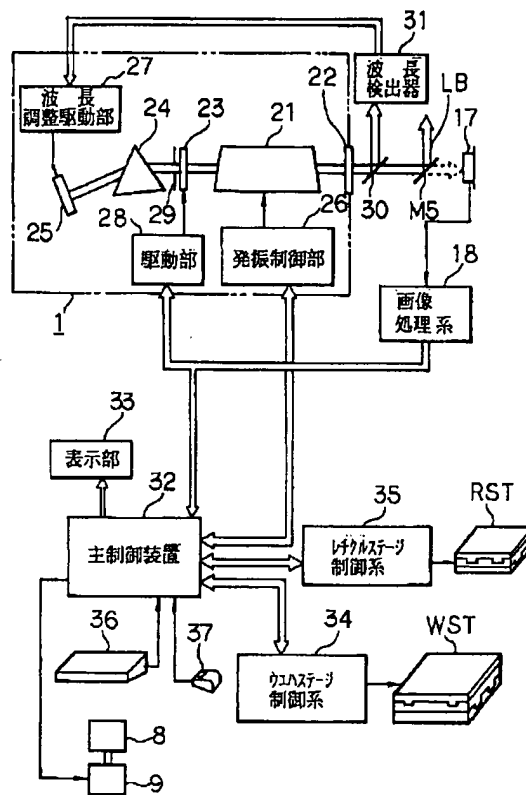8　振動ミラー
15　照明領域
17　2次元撮像素子
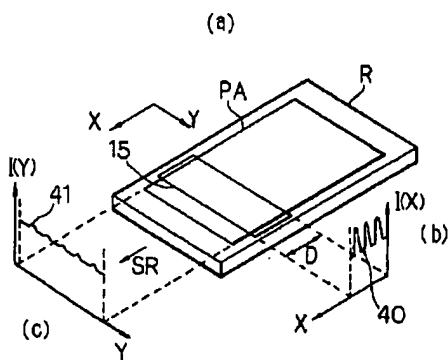18　画像処理系
R　レチクル
PL　投影光学系
W　ウエハ
RST　レチクルステージ
WST　ウエハステージ

【図3】

【図1】

【図2】

【図4】

(a)

【図6】
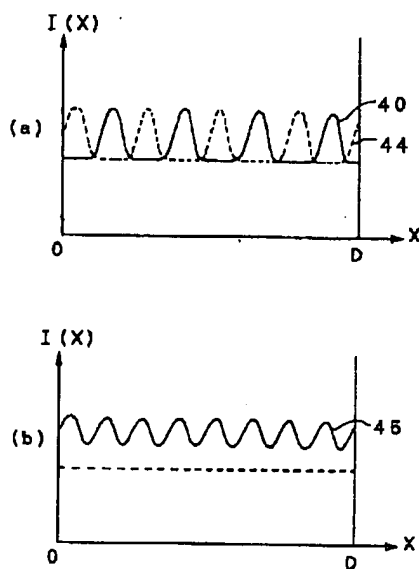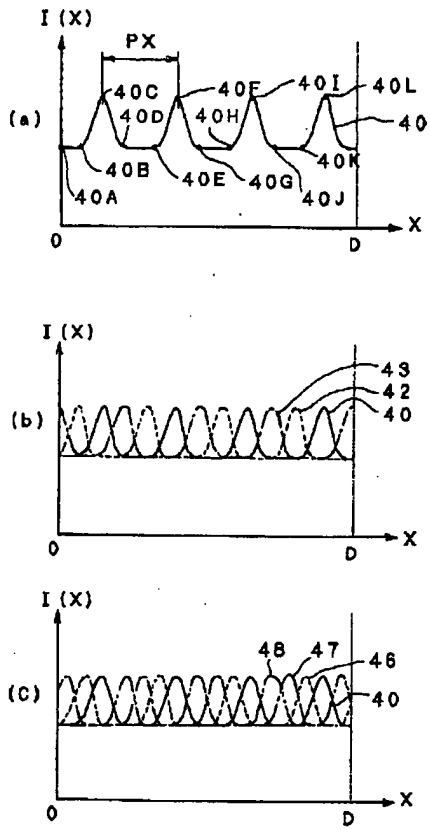
【図5】

【図7】